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Recent Advances in Construction Project Management: A Systematic Literature Review of Digital Transformation

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ABSTRACT

Construction project management has undergone significant transformation due to rapid advances in digital technologies, sustainability initiatives, and innovative management approaches. This systematic literature review examines research published between 2019 and 2023 to identify recent developments, emerging trends, implementation challenges, and future research opportunities in construction project management. The reviewed studies reveal that technologies such as Building Information Modeling (BIM), Artificial Intelligence (AI), the Internet of Things (IoT), Digital Twins, cloud computing, and data analytics have significantly enhanced project planning, scheduling, cost estimation, risk management, quality control, and decision-making. Furthermore, sustainable construction practices and integrated project delivery methods have improved collaboration among project stakeholders while promoting resource efficiency and environmental performance. Despite these advancements, challenges remain regarding technology adoption, interoperability, workforce competency, cybersecurity, and organizational resistance to digital transformation. Future research should focus on intelligent project management systems, standardized digital frameworks, and sustainable management strategies to improve project performance, resilience, and productivity across the construction industry.

Keywords: *Artificial Intelligence, Building Information Modeling, Construction Project Management, Digital Transformation, Sustainable Construction.*

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1. | INTRODUCTION

The construction industry has experienced substantial transformation over the past decade due to rapid technological advancement, increasing project complexity, and growing demands for sustainability, productivity, and cost efficiency (Hughes et al., 2022). Construction projects today involve multiple stakeholders, extensive information exchange, strict regulatory requirements, and complex resource management processes that require effective project management throughout the entire project lifecycle. Consequently, construction project management has evolved from conventional planning and supervision practices toward intelligent, data-driven, and collaborative management systems supported by digital technologies. These developments have significantly improved project planning, scheduling, cost control, quality management, risk assessment, and stakeholder coordination, enabling construction organizations to deliver projects more efficiently while meeting sustainability objectives.

Digital transformation has become one of the primary drivers of innovation in construction project management. Among the most influential technologies, Building Information Modeling (BIM) has fundamentally changed the way construction projects are designed, coordinated, and managed. BIM provides a comprehensive digital representation of physical and functional building characteristics that facilitates collaboration among architects, engineers, contractors, and project owners. Through centralized information management, BIM minimizes design conflicts, improves communication, enhances construction planning, and supports more accurate cost estimation and scheduling. Recent studies further indicate that integrating BIM with cloud computing and mobile technologies enables real-time information sharing, thereby improving decision-making and project transparency throughout the construction lifecycle.

Artificial Intelligence (AI) has also become an increasingly important component of modern construction project management. Machine learning algorithms, predictive analytics, and intelligent optimization techniques are now widely applied to forecast project performance, estimate construction costs, identify project risks, optimize resource allocation, and support automated decision-making. AI-driven systems can analyze large volumes of historical and real-time project data to detect patterns that improve scheduling accuracy, predict delays, and recommend corrective actions before significant project disruptions occur. As a result, construction managers can make faster and more informed decisions while improving productivity and reducing project uncertainty.

The emergence of the Internet of Things (IoT) and Digital Twin technologies has further accelerated innovation in construction management. IoT-enabled sensors continuously collect real-time information regarding equipment performance, material conditions, worker safety, environmental factors, and construction progress. When integrated with Digital Twin platforms, this operational data creates dynamic virtual models capable of simulating construction activities, monitoring project performance, and supporting predictive decision-making. These technologies enable project managers to evaluate alternative construction scenarios, optimize resource utilization, and identify operational issues before they affect project performance. Consequently, Digital Twins have become an essential tool for intelligent construction management and lifecycle asset optimization.

Another significant trend identified in recent literature is the growing emphasis on sustainable construction project management. Environmental sustainability has become a major consideration throughout planning, procurement, construction, and facility operation. Project managers increasingly incorporate sustainable construction principles such as energy efficiency, waste reduction, lifecycle assessment, carbon emission mitigation, and green building certification into project management practices. Digital technologies facilitate these objectives by enabling more accurate environmental analysis, efficient resource utilization, and continuous performance monitoring throughout the building lifecycle. Furthermore, integrated project delivery (IPD) and collaborative contract models have improved stakeholder coordination, minimized project conflicts, and enhanced project outcomes by encouraging transparent communication and shared responsibilities among project participants.

Despite these technological advancements, numerous challenges continue to affect construction project management implementation. High implementation costs, interoperability among digital platforms, limited digital competencies, organizational resistance to technological change, fragmented project information, and cybersecurity risks remain major barriers to successful digital transformation. Small and medium-sized construction enterprises often face additional constraints related to financial resources, technical expertise, and digital infrastructure. Moreover, integrating emerging technologies with existing project management practices requires standardized information exchange protocols, effective change management strategies, and continuous professional training to maximize organizational benefits.

Given these developments, construction project management has become an increasingly multidisciplinary field integrating engineering, information technology, management science, and sustainability principles (Marcos et al., 2020). Continuous technological innovation is reshaping project planning, execution, monitoring, and maintenance while improving collaboration and decision-making throughout project lifecycles. Therefore, this study presents a systematic literature review of research published between 2019 and 2023 to examine recent developments in construction project management. The review aims to identify current research trends, technological innovations, implementation strategies, existing challenges, and future research opportunities that contribute to improving project performance, sustainability, and digital transformation within the global construction industry.

2. | RESEARCH METHOD

This study adopted a Systematic Literature Review (SLR) approach to investigate recent developments in construction project management and to synthesize current scientific evidence regarding emerging technologies, management strategies, implementation challenges, and future research directions. The SLR methodology was selected because it provides a rigorous, transparent, and reproducible framework for collecting, evaluating, and synthesizing findings from existing studies. The review focused on peer-reviewed journal articles published between 2019 and 2023, ensuring that the analysis reflects the latest advancements in construction project management and digital transformation within the Architecture, Engineering, and Construction (AEC) industry (Casini, M. 2021). Relevant publications were identified through internationally recognized scientific databases, including Scopus, Web of Science, ScienceDirect, SpringerLink, IEEE Xplore, and MDPI. The literature search employed combinations of keywords such as construction project management, Building Information Modeling (BIM), digital transformation, Artificial Intelligence (AI), Internet of Things (IoT), Digital Twin, construction planning, project scheduling, risk management, cost management, sustainable construction, and project performance.

The literature selection process followed four systematic stages: identification, screening, eligibility assessment, and final inclusion. Duplicate records, conference proceedings, editorials, review papers, book chapters, and studies not directly related to construction project management were excluded from the review (Siddaway et al., 2019). Only English-language journal articles with clearly defined research objectives, methodologies, and findings were included in the final analysis (Riazi et al., 2020). Subsequently, the selected studies were examined to extract information regarding technological innovations, project management functions, digital applications, sustainability practices, stakeholder collaboration, implementation barriers, and future research opportunities. The extracted data were organized into thematic categories to facilitate comparative analysis and identify dominant research trends (Dora & Kumar, 2020). Finally, a qualitative synthesis was conducted to integrate the findings from the selected literature, providing a comprehensive understanding of how recent technological developments have transformed construction project management and contributed to improving project efficiency, sustainability, collaboration, and overall performance within the modern construction industry (Roy & Roy, 2021).

3. | RESULTS AND DISCUSSION

The systematic literature review indicates that construction project management has undergone substantial transformation between 2019 and 2023, driven by rapid advances in digital technologies, sustainable construction practices, and integrated management approaches (Omrany et al., 2023). The reviewed studies consistently demonstrate that construction projects are becoming increasingly data-driven, collaborative, and technology-oriented to improve project efficiency, quality, safety, and sustainability. Modern project management has evolved beyond conventional planning and monitoring methods by incorporating Building Information Modeling (BIM), Artificial Intelligence (AI), the Internet of Things (IoT), Digital Twins, cloud computing, and big data analytics into project delivery processes. These innovations enable project stakeholders to make informed decisions based on real-time information while improving communication, reducing project risks, and optimizing resource utilization (Nabeel, 2024).

One of the most significant findings identified in the reviewed literature is the increasing implementation of Building Information Modeling (BIM) as the foundation of digital construction project management. BIM provides an integrated digital environment where architectural, structural, mechanical, and construction information can be shared among project stakeholders throughout the project lifecycle. Compared with traditional document-based management systems, BIM significantly improves design coordination, clash detection, scheduling, quantity take-off, cost estimation, and construction planning. The reviewed studies indicate that BIM contributes to reducing design errors, minimizing project delays, improving collaboration, and enhancing construction productivity. Furthermore, cloud-based BIM platforms allow multidisciplinary teams to collaborate remotely using centralized project information, thereby improving communication efficiency and reducing information fragmentation (Teisserenc & Sepasgozar, 2021).

Artificial Intelligence has become another major technological advancement influencing modern construction project management. Machine learning algorithms, predictive analytics, and optimization techniques are increasingly applied to improve project scheduling, resource allocation, risk assessment, cost estimation, and quality control (Pellerin & Perrier, 2019). AI-based systems can analyze historical and real-time project data to identify potential delays, estimate project completion times, predict budget deviations, and recommend corrective actions before significant problems occur. Deep learning algorithms have also demonstrated promising performance in construction safety monitoring by automatically detecting unsafe worker behavior, identifying hazardous working conditions, and improving accident prevention strategies. Consequently, AI has become an essential decision-support technology that enhances both project efficiency and operational safety (Rane, 2023).

The literature further highlights the growing adoption of Internet of Things (IoT) technologies in construction project management. Smart sensors installed on construction equipment, materials, and project sites continuously collect operational data regarding equipment utilization, environmental conditions, structural performance, worker locations, and construction progress (Khan et al., 2022). These real-time datasets enable project managers to monitor project activities continuously and respond rapidly to unexpected events. IoT-based monitoring systems also improve equipment maintenance planning by detecting abnormal operating conditions before equipment failures occur. In addition, wearable devices equipped with IoT sensors have enhanced occupational health and safety by monitoring workers' physical conditions and environmental exposure during construction activities. These technological developments improve project reliability while supporting more efficient site management and operational control (Choi et al., 2022).

Another important trend identified in the reviewed studies is the emergence of Digital Twin technology within construction project management. Digital Twins create dynamic virtual representations of physical construction assets by continuously integrating data collected from BIM models, IoT sensors, drones, and project management systems. This digital environment enables engineers and project managers to simulate construction activities, evaluate project performance, predict operational risks, and optimize project execution before implementing decisions on-site. Digital Twin technology further supports predictive maintenance and lifecycle asset management by continuously monitoring infrastructure performance after project completion. As a result, Digital Twins have become valuable tools for improving project quality, reducing operational uncertainty, and supporting long-term infrastructure sustainability (Pericault et al., 2023).

Sustainability has also emerged as a central component of recent construction project management practices. The reviewed literature indicates that project managers increasingly integrate environmental considerations into planning, procurement, construction, and facility management. Digital technologies facilitate lifecycle assessment, carbon emission analysis, energy performance evaluation, waste reduction, and efficient material utilization throughout project execution. BIM-based sustainability assessment tools enable project teams to evaluate multiple design alternatives based on environmental performance before construction begins, thereby supporting more sustainable decision-making. Furthermore, integrated project delivery approaches encourage collaboration among owners, designers, contractors, and consultants to improve project efficiency while minimizing environmental impacts. These developments demonstrate that sustainable construction management has become closely aligned with global initiatives promoting resilient infrastructure and responsible resource utilization. Cloud computing and big data analytics have also become fundamental technologies supporting modern construction project management. Construction projects generate enormous volumes of information from design documents, Building Information Modeling (BIM), project schedules, financial records, procurement activities, equipment monitoring systems, and field inspections (Love et al., 2019). Cloud-based platforms provide centralized data storage that enables project stakeholders to access, update, and exchange project information in real time regardless of geographical location. This capability significantly improves communication, document management, and decision-making throughout project execution. Meanwhile, big data analytics allows project managers to identify performance trends, evaluate project progress, forecast resource requirements, and optimize project delivery based on historical and real-time information. Consequently, cloud computing has become an essential infrastructure for digital collaboration and integrated construction management, particularly in large and complex infrastructure projects.

Risk management has experienced substantial improvement through the integration of intelligent digital technologies. Traditional risk assessment methods often depend on expert judgment and historical experience, which may limit the accuracy of project predictions. Recent studies indicate that artificial intelligence, machine learning, and predictive analytics improve risk identification by processing large datasets associated with project schedules, labor productivity, weather conditions, financial performance, and supply chain activities. These technologies enable project managers to estimate the probability of delays, cost overruns, safety incidents, and resource shortages before they occur. In addition, simulation techniques supported by Digital Twin platforms allow engineers to evaluate multiple project scenarios and identify the most effective mitigation strategies (Achakulwisut et al., 2023). Such data-driven approaches improve project resilience while supporting proactive decision-making throughout the construction lifecycle.

The reviewed literature further highlights the increasing application of advanced technologies for improving construction safety management. Occupational health and safety remain major concerns because construction activities involve hazardous working environments and complex operational processes. Artificial intelligence combined with computer vision technologies enables automated monitoring of construction sites using surveillance cameras, unmanned aerial vehicles (UAVs), and image recognition algorithms. These systems are capable of detecting unsafe worker behavior, identifying the absence of personal protective equipment, recognizing hazardous site conditions, and issuing real-time safety alerts. Furthermore, wearable smart devices equipped with Internet of Things (IoT) sensors continuously monitor workers' locations, physical conditions, and environmental exposure, thereby improving emergency response and accident prevention. These technological innovations contribute to safer working environments while reducing project interruptions caused by workplace accidents (Yaris et al., 2020).

Despite these technological advancements, several implementation challenges continue to influence the successful adoption of digital construction project management (Hwang et al., 2022). One of the most frequently reported barriers is the high initial investment required for software acquisition, digital infrastructure, intelligent sensing technologies, and workforce training. Small and medium-sized construction enterprises often face financial limitations that reduce their ability to implement advanced digital solutions. In addition, interoperability among heterogeneous software platforms remains a major technical challenge. Construction organizations frequently utilize multiple software applications for architectural design, structural analysis, scheduling, quantity surveying, procurement, and facility management. Differences in data formats and proprietary software standards often reduce information compatibility and create inefficiencies in project coordination. Strengthening open data standards and improving software interoperability have therefore become important research priorities for achieving fully integrated digital construction ecosystems.

Cybersecurity has also emerged as an increasingly important issue as construction management systems become more connected through cloud computing, IoT networks, and mobile collaboration platforms. Modern construction projects involve continuous exchange of sensitive engineering data, financial information, contractual documentation, and operational records across multiple digital environments. Unauthorized access, cyberattacks, and data manipulation may compromise project security, delay project execution, and generate substantial financial losses. Consequently, recent studies emphasize the implementation of secure communication protocols, data encryption, authentication mechanisms, access control systems, and cybersecurity governance frameworks to ensure information confidentiality and operational reliability. Developing secure digital infrastructures will remain essential as the construction industry continues its transition toward highly connected project management systems.

Another important finding identified throughout the reviewed literature is the increasing emphasis on sustainable project management. Construction organizations are integrating environmental, economic, and social sustainability into project planning and execution to support global sustainable development objectives. Digital technologies facilitate lifecycle assessment, carbon emission analysis, waste minimization, resource optimization, and energy-efficient construction planning. Sustainable procurement strategies, circular economy principles, and green building certification systems are increasingly incorporated into project management practices to improve environmental performance without compromising project quality or financial viability. These developments demonstrate that sustainability has become an integral component of modern construction management rather than an additional project objective.

Future research is expected to focus on strengthening the integration of Building Information Modeling, Artificial Intelligence, Digital Twins, blockchain, robotics, augmented reality (AR), virtual reality (VR), and advanced data analytics within construction project management. Explainable artificial intelligence is anticipated to improve the transparency and reliability of automated decision-support systems, while blockchain technology may enhance information security, contract management, and supply chain transparency. Furthermore, greater integration of Digital Twins with real-time sensing technologies will enable continuous monitoring of project performance throughout the infrastructure lifecycle. These technological developments are expected to accelerate the digital transformation of the Architecture, Engineering, and

Construction (AEC) industry while improving project efficiency, sustainability, resilience, and stakeholder collaboration (Almusaed et al., 2023).

Overall, the findings of this systematic literature review demonstrate that construction project management has evolved into a multidisciplinary digital management system integrating advanced information technologies, intelligent decision-support tools, and sustainable management principles. The convergence of Building Information Modeling, Artificial Intelligence, the Internet of Things, cloud computing, Digital Twins, and big data analytics has significantly enhanced planning, scheduling, cost control, risk management, quality assurance, and project collaboration. Although challenges related to implementation costs, interoperability, cybersecurity, and workforce readiness remain, continuous technological innovation and increasing industry adoption are expected to further improve construction project performance (Maskuriy et al., 2019). Consequently, digital construction project management will continue to play a vital role in supporting sustainable infrastructure development, improving organizational competitiveness, and achieving the objectives of Construction 4.0 in the coming years.

4. | CONCLUSION

This systematic literature review demonstrates that construction project management has experienced significant transformation through the adoption of digital technologies and sustainable management practices between 2019 and 2023. The reviewed studies indicate that Building Information Modeling (BIM), Artificial Intelligence (AI), the Internet of Things (IoT), Digital Twins, cloud computing, and big data analytics have become key technologies for improving project planning, scheduling, cost estimation, risk management, quality control, and stakeholder collaboration. These technological innovations enable project managers to make data-driven decisions, optimize resource utilization, reduce project delays, improve construction safety, and enhance overall project performance throughout the project lifecycle. Furthermore, the integration of sustainability principles into project management has strengthened efforts to minimize environmental impacts, improve resource efficiency, and support resilient infrastructure development.

Despite these advancements, several challenges continue to influence the successful implementation of digital construction project management. High implementation costs, software interoperability, cybersecurity risks, limited digital competencies, and organizational resistance remain significant barriers, particularly for small and medium-sized construction organizations. Addressing these issues requires stronger collaboration among researchers, industry practitioners, technology providers, educational institutions, and policymakers to develop standardized digital frameworks and enhance workforce capabilities. Future research should prioritize intelligent project management systems, explainable artificial intelligence, Digital Twin integration, blockchain-based information management, and advanced decision-support technologies to further improve construction productivity, sustainability, and resilience. These developments are expected to accelerate the digital transformation of the construction industry and support the delivery of more efficient, sustainable, and high-quality infrastructure projects.

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The authors declare that there is no conflict of interest.

Ethical Approval and Originality Statement

Ethical approval was obtained for this study. The manuscript represents original work and has not been previously published, nor is it under consideration by another journal.

Data Disclosure Statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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